A STUDY ON BLENDING EFFECTS OF BIODIESEL WITH PURE DIESEL

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I declare that this thesis entitled **"THE STUDY OF BLENDING EFFECTS OF BIODIESEL WITH PURE DIESEL"** is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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To the most dearest and beloved mother and father

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ABSTRACT

Biodiesel is a very attractive source of fuel because it is renewable. It can be used either pure or in blends with diesel fuel in unmodified diesel engines. It reduces some exhaust pollutants and can be produced easily from common feedstock. However, the relative simplicity of biodiesel production can disguise the importance of maintaining high quality standards for any fuel supplied to a modern diesel engine. The purpose of this study is to improve biodiesel properties by blending it with pure diesel and to measure the basic properties of waste palm oil biodiesel-diesel fuel blends according to the standard specifications of diesel fuels. Therefore, effects of blending biodiesel with petrodiesel are analyzed. Neat fuels are designated as B100 and B0, respectively. The samples of biodiesel-petrodiesel blends consist of B0, B5, B10, B20, B30, B40, B50, B60, B70, B80, B90, and B100. The total blended fuel was taken for 25 ml for all analysis except for combustion test where it requires 1.5 L of the blended fuel. All these samples have gone through five types of fuel analysis namely viscosity test, moisture content, acid value, TLC test and combustion test. From the results of the analysis, it is found out that optimum of volume ratio mixing in order to improve the cold flow properties if biodiesels are used under severe winter conditions. The most optimum range for biodiesel-diesel blending is from B20 until B50. Range from B20 to B50 gives the most optimum condition for engine fuel. Fuels below B20 have a better quality as they contain as less moisture content as possible where most of them have moisture content below than 0.05%. On the other hand, blended fuels above B50 that contain more amount of biodiesel increases the amount of methyl ester, more than 0.68 conversions. The emission particulates can also be improved when optimum amount of biodiesel is blended to the

petrodiesel. The amount of O_2 is more than 8.3% starting form B20 onwards. The amount of CO_2 was able to be reduced from 9.4% downwards starting from B20 until B100. Oppositely, the amount of NO_x was the highest at B100 which is 31 ppm and the lowest at B0 which is 3 ppm. The amount of free fatty acid also increases as the volume ratio of biodiesel increase. At B0, there is no presence of free fatty acid. At B100, the value of free fatty acid is the highest which is 0.62 ml NaOH/g and 1.3 ml NaOH/g for acid value.

ABSTRAK

Biodiesel adalah sesuatu yang menarik kerana ia adalah sumber yang boleh diperbaharui dan ia boleh digunakan sama ada dalam bentuk asli atau pun dicampur bersama petrol-diesel di enjin-enjin biasa. Penggunaannya juga boleh mengurangkan pembebasan gas-gas pencemaran. Ianya juga menarik kerana ia boleh dihasilkan daripada sumber tanaman dan ternakanyang biasa didapati. Bagaimanapun penghasilan biodiesel yang relative kepada sumber minyak ini tidak semestinya memenuhi piawaian minyak berkualiti tinggi yang digunakan pada masa kini. Tujuan penyelidikan ini adalah untuk memperbaiki sifat-sifat biodsel serta mengkaji sifat asas minyak campuran berdasarkan piawai spesifikasi untuk minyak diesel. Oleh itu, kesan pembancuhan biodiesel bersama petrodiesel dikaji. Minyak yang digunakan sebagai kawalan analisis adalah B0 sebagai minyak petrodiesel asli dan B100 sebagai minyak biodiesel asli. Sample-sampel biodiesel-petrodiesel yang telah dibancuh terdiri daripada B0, B5, B10, B20, B30, B40, B50, B60, B70, B80, B90 dan B100. Kesemua sampel ini melalui lima jenis analisis iaitu ujian kelikatan, kandungan lembapan air, nilai asid, ujian TLC dan ujian pembakaran. Jumlah bancuhan minyak biodiesel dan petrodiesel adalah sebanyak 25 ml untuk setiap analisis kecuali untuk analis pembakaran di mana analisis tersebut memerlukan 1.5 liter bancuhan minyak. Setelah menjalani kesemua analisis tersebut, didapati bahawa nisbah campuran isipadu yang optimum dari B20 sehingga B50 boleh memperbaiki sifat aliran sejuk minyak biodiesel untuk negara bercuaca sejuk. Campuran minyak daripada B20 ke bawah mempunyai kualiti yang lebih baik kerana mereka mempunyai kandungan mendapan air yang kurang daripada 0.05%. Sebaliknya, minyak campuran yang

lebih daripada B50 mengandungi lebih banyak biodiesel meningkatkan kandungan methyl ester, lebih daripada 68%. Sifat pembakaran juga dapat diperbaiki pada nisbah optimum bancuhan biodiesel kepada diesel.Kandungan O_2 adalah lebih daripada 8.3% pada B20 dan ke atas. Kandungan CO_2 dapat dikurangkan dari 9.4% ke bawah bermula daripada B20 sehingga B100. sebaliknya, kandungan NOx adalah paling tinggi pada B100 iaitu 31 ppm dan paling rendah pada B0 iaitu 3 ppm. Kandungan asid lemak juga bertambah apabila nisbah bancuhan biodiesel bertambah. Pada B0, didapati tiada kandungan asid lemak. Pada B100, kandungan asid lemak adalah yang paling tinggi iaitu 0.62 ml NaOH/g dan 1.3 ml NaOH/g untuk nilai asid.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Biodiesel is an alternative fuel for diesel engines that is receiving great attention world wide. Not only can it be obtained from living plants such as soy oil, sunflower seeds vegetable oil but also from our everyday domestic waste, the waste cooking oil. In the recent years biodiesel, consisting in esters of fatty acids with short chain alcohols, mainly methanol, gained an important position as an environmentally friendly substitute of Diesel fuel. It is biodegradable, non-inflammable, non-toxic, producing much less carbon monoxide, sulfur dioxide and unburned hydrocarbons than petroleum-based diesel. Beside of many advantages that biodiesel has over Diesel fuel, the most important are the reduction of greenhouse gas effect and emissions from exhaust gas combustion.

Although it attracts the most attention because it is renewable, it can be used either pure or in blends with diesel fuel in unmodified diesel engines, and it reduces some exhaust pollutants. It is also attractive because it can be produced easily from common feedstocks. However, the relative simplicity of biodiesel production can disguise the importance of maintaining high quality standards for any fuel supplied to a modern diesel engine. It is essential to the growth of the biodiesel industry that all fuel produced and sold meet these quality standards (J. Van Gerpen *et al*, 2004).

Technically, biodiesel is a methyl ester of a fatty acid (or shortly known as FAME). It is most commonly produced by reacting lipids (triglycerides) with a primary alcohol (methanol). Used cooking oil and animal fats consist of mixtures of triglyceride molecules; they are the esters of a tri-alcohol (glycerol) with three different fatty acids. One of the biological functions of triglycerides is its use as a fuel.

The viscosity of used cooking oils is 10–20 times higher than of petroleum fuel, therefore using directly used cooking oils as a fuel can cause engine problems like injector fouling and particle agglomeration. (Carmen Stavarache et al, 2006). Biodiesel has a relatively high flash point (150 °C), which makes it less volatile and safer to transport or handle than petroleum diesel. It provides lubricating properties that can reduce engine wear and extend engine life. In brief, these merits of biodiesel make it a good alternative to petroleum-based fuel and have led to its use in many countries, especially in environmentally sensitive areas (Y. Zhang *et al*, 2003). Biodiesel is an alternative diesel fuel consisting of the alkyl monoesters of fatty acids from vegetable oils and animal fats. Biodiesel can be used in diesel engines as a pure fuel or in blends with petroleum-based diesel fuel. To maintain optimum performance and meet emission regulations, it may be necessary to measure the composition of blended fuels and adjust the fuel injection timing and other injection parameters during operation (J. Van Gerpen *et al*, 2004).

1.2 Transesterification of Waste Cooking Oil

One approach for reducing the viscosity of waste cooking oils is transesterification. Transesterification is a chemical process of reacting vegetable oils with alcohol in the presence of a catalyst. Transesterification significantly reduces the viscosity of waste cooking oils without affecting the heating value of the original fuel. (Carmen Stavarache *et al*, 2006). Therefore, fuel atomization, combustion, and emission characteristics will display better results than pure waste cooking oil if the esters of the oils are used in engines. Alcohols such as ethanol, methanol, or butanol can be used in the transesterification and the monoesters are named methyl esters, ethyl esters or butyl esters, respectively. The catalysts used in transesterification are generally classified in two categories, acidic and alkaline (Y. Zhang *et al*, 2003). Each acid and base catalyst also has two types of phase that is homogeneous and heterogeneous. Heterogeneous catalyst seems to have some advantages since it is immiscible with the waste cooking oil.

1.3 Primary Reasons For Encouraging The Development Of Biodiesel

1.3.1 Market For Excess Production Of Vegetable Oils And Animal Fats

There is increasing demand around the world for soybean meal to provide protein for human and animal consumption. If new markets are not found for the soybean oil, then the price of soy beans will be low and farmers will have even more difficulty producing a profit. The animal by-products industry also has a problem with more supply than the current market demands.

1.3.2 Sources of Fuel

Obviously, this reason should not be overemphasized since the percentage of the country's fuel supply that can be replaced with biodiesel will be small. However, petroleum markets tend to be sensitive to small fluctuations in supply so an additional source of fuel can have a surprising impact on stabilizing fuel prices.

1.3.3 Biodiesel As Environmentally Friendly, Renewable And Biodegradable Fuel

Because the primary feedstock for biodiesel is a biologically-based oil or fat that can be grown season after season, biodiesel is renewable. And, since the carbon in the fuel was originally removed from the air by plants, there is no net increase in carbon dioxide levels. Again, this reason should not be overemphasized because biodiesel does not have the potential to make a major impact on total carbon dioxide production. It should also be noted that the primary alcohol used to produce biodiesel is methanol. Methanol makes up about 10% of the feed stock input and since most methanol is currently produced from natural gas, biodiesel is not completely renewable.

1.3.4 Lower Exhaust Emissions

Biodiesel provides substantial reductions in carbon monoxide, unburned hydrocarbons, and particulate emissions from diesel engines. While the carbon monoxide and unburned hydrocarbons from diesels are already low compared with gasoline engines, biodiesel reduces them further. Particulate emissions, especially the black soot portion, are greatly reduced with biodiesel. Unfortunately, most emissions tests have shown a slight oxide of nitrogen (NOx) increase with biodiesel. This increase in NOx can be eliminated with a small adjustment to the engine's injection timing while still retaining a particulate reduction.

1.3.5 Excellent Lubricating Properties

Even when added to regular diesel fuel in an amount equal to 1-2% (volume %), it can convert fuel with poor lubricating properties, such as ultra-low-sulfur diesel fuel, into an acceptable fuel.

1.4 Problem Statement

Biodiesel can be used neat or blended in existing diesel engines without significant modifications to the engine. However, differences in the chemical nature of biodiesel (mixture of mono-alkyl ester of saturated and unsaturated long chain fatty acids) and conventional diesel fuel (mixture of paraffinic, naphthenic and aromatic hydrocarbons) result in differences in their basic properties, affecting engine performance and pollutant emissions. In order to predict these properties, mixing rules are evaluated as a function of the volume fraction of biodiesel in the blend.

1.5 Objective Of The Study Case

The main objective of this experiment is to improve biodiesel properties by blending it with pure diesel and to measure the basic properties of waste palm oil biodiesel-diesel fuel blends according to the standard specifications of diesel fuels.

1.6 Scope Of Study

In order to achieve the objective, the effect of blending waste cooking oil biodiesel with pure diesel will be analyzed in terms of viscosity, free fatty acid content, moisture content, cloud point, flash point, cetane number and heating value.

1.6.1 Waste Cooking Oil

At present, the high cost of biodiesel is the major obstacle to its commercialization. It is reported that the high cost of biodiesel is mainly due to the cost of virgin vegetable oil (Krawczyk, 1996; Connemann and Fischer, 1998). Therefore, it is not surprising that biodiesel produced from pure soybean oil costs much more than petroleum-based diesel. Exploring ways to reduce the high cost of biodiesel is of much interest in recent biodiesel research, especially for those methods concentrating on minimizing the raw material cost. The use of waste cooking oil instead of virgin oil to produce biodiesel is an effective way to reduce the raw material cost because it is estimated to be about half the price of virgin oil (Supple *et al*., 1999). In addition, using waste cooking oil could also help to solve the problem of waste oil disposal (Wiltsee, *et al* 1998).

1.6.2 Blending Preparation

Although several blends with a wide composition spectrum are prepared by splash blending, most of the tests are carried out with B5 (5% POB-95% D by volume) and B20 blends, due to their widespread use. Neat fuels are designated as B100 and B0, respectively. Blends are prepared on a volume basis at 25°C. Although blend preparation on a weight basis has the advantage that weight fraction does not change with temperature, the common practice in the fuel industry is to carry out the mixing process on a volume basis at the ambient temperature of the blending location, usually a wholesale commercial plant (P.Benjumea *et all*,2007). For this reason, the option selected in this work is to use blending rules as a function of volumetric fractions.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

It is estimated that in the coming years, the fossil oil price will increase because the oil production cannot meet the projected demand due to oil depletion. This is because of the over consumption in the developing countries to generate their fuel diesel, electric power, hydrogen or natural gas for internal combustion-machines. As mentioned earlier, biodiesel is commercially produced to substitute the petrol-diesel to sustain our energy consumption for many applications. Biodiesel can be obtained from various sources such as soy oil, sunflower seed oil, vegetable oil, waste cooking oil or even algae.

Different region would have chosen different method depending on each own climate and geological most grown plants. For example, soy oil in US and Taiwan, vegetable oil in Japan and China. As for Malaysia, most of the materials can be found here but since Malaysia is rich for its oily food, it is best to choose waste cooking oil as the raw material for biodiesel production.

2.2 Biodiesel

Since Malaysia is famous for a wide variety of food, cooking oil has become the major material used in cooking. There are many food outlets in Malaysia that potentially have waste cooking oil. Used cooking oil can be converted to biodiesel by enabling its transesterification. The European countries had started the earlier method of stimulating the transesterification reaction by mixing and blending the oil together with alcohol. However, Malaysia needs a more convenient way to produce more biodiesel within lesser processing time at lower cost.

Biodiesel has been defined as the monoalkyl esters of long-chain fatty acids, preferentially methyl and ethyl esters, derived from renewable feedstocks, such as vegetable oils or animal fats. It is now mainly being produced from soybean, rapeseed and palm oils. Its properties are close to diesel fuels, and therefore biodiesel becomes a strong candidate to replace the diesel. It probably has better efficiency than petrol-oil. Recently, because of increases in crude oil prices, limited resources of fossil oil, environmental concerns, population increase and hence, higher energy demand, biodiesel represents a promising alternative fuel for use in compression ignition (diesel) engines.

An alternative fuel to petrodiesel must be technically feasible, economically competitive, environmentally acceptable and easily available. This current alternative diesel fuel can be termed as biodiesel. Biodiesel use may improve emissions levels of some pollutants and deteriorate other. However, for quantifying the effect of biodiesel it is important to take into account several other factors such as raw material, driving cycle, vehicle technology etc. Usage of biodiesel will allow a balance to be sought between agriculture, economic development and the environment.

Biodiesel is not only from renewable sources such as sunflower seeds, soy, algae, palm oil, and many more but it can also be obtained from waste cooking oil. Chemically, greases and oils are classified as triglycerides. However, oils are generally considered to be liquids at room temperature, while greases and fats are solid at room temperature. Many animal fats and hydrogenated vegetable oils tend to be solid at room temperature. Both hydrogenated and non-hydrogenated vegetable oils are used in commercial food frying operations. Recycled grease products are referred to as waste grease. Greases are generally classified in two categories, yellow grease and brown grease. The main sources of animal fat*s* are primarily meat animal processing facilities.

Another source of animal fats is the collection and processing of animal mortalities by rendering companies. Yellow grease is produced from vegetable oil or animal fat that has been heated and used for cooking a wide variety of meat, fish or vegetable products. Renderers filter out the solids and heat the spent cooking oil to drive out moisture until it meets industry specifications for yellow grease. Yellow grease is required to have a free fatty acid (FFA) level of less than 15%. If the FFA level exceeds 15%, it is called brown grease, sometimes referred to as trap grease, and it may be sold at a discount, or blended with low FFA material to meet the yellow grease specifications.

Trap grease is a material that is collected in special traps in restaurants to prevent the grease from entering the sanitary sewer system where it could cause blockages. Many rendering plants will not process trap grease because it is usually contaminated with cleaning agents. Waste vegetable oils and fats are generally low in cost and are currently collected from large food processing and service facilities. They are then rendered and used almost exclusively in animal feed. Brown grease is often cited as a potential feedstock for biodiesel because it currently has very low value. However waste vegetable oil from restaurants and